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A DECADE'S OVERVIEW OF IO'S VOLCANIC ACTIVITY D. L. Matson, G. J. Veeder, T. V. Johnson, D. L. Blaney, and J. D. Goguen, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109.

Over the past decade some aspects of Io's volcanic activity have changed greatly, while others have essentially remained constant. This contrast has emerged from our study of multi-wavelength, infrared, observations of Io's thermal emission. From 1983 to 1992 we observed the disk integrated flux density of Io from the NASA Infrared Telescope Facility (IRTF) on Mauna Kea, Hawaii. Our spectral coverage allows us to separate out the emission components due to volcanic thermal anomalies which are warmer than the background emission caused by solar heating. Our temporal coverage allows us to resolve individual eruptions and also to obtain the disk-integrated flux density as a function of longitude (or, equivalently, orbital phase angle). [1]. Characteristics that persisted over the decade involve (1) Loki's location and intensity of emission , (2) the leading hemisphere emission, and (3) the average heat flow. The variable aspects of Io over the decade include (1) Loki's hotter area(s), and (2) the outbursts in the leading hemisphere.

Persistent Characteristics: (1) the location of Loki and its status as the brightest thermal anomaly, (2) the level of activity in the leading hemisphere, and (3) the average heat flow. Loki has consistently been the major thermal anomaly on Io. This is evident in our longitude data, a sample of which is plotted in the Fig. 1. While our data set does not yield latitude, this emission peak has always been found to be associated with Loki whenever its position has been observed by other techniques (e. g., polarimetry [2], occultation photometry [3], infrared imagery from the IRTF [4], and, of course, Voyager [5]).

The leading hemisphere (0-180°W) has consistently shown an excess of thermal emission above that due purely to the absorption of sunlight, although its emission is generally less than that of the trailing hemisphere (180-360°W). On the leading hemisphere there is no source equivalent to Loki and there is no apparent longitudinal concentration of thermal anomalies.

The average heat flow from volcanic regions during the decade is relatively constant, at about 9×10^{13} W (~ 2 W m^{-2} averaged over Io's surface). This value is a preliminary estimate based upon an assumed distribution of thermal anomalies [6] and a "quick-look" subset of the data. The heat flow value will be refined as we carry out the detailed analysis of the whole data set. The lack of error bars is intentional. While the yearly scatter is typically less than about thirty percent, systematic errors (such as possible unrecognized small thermal anomalies and uncertainties in the latitudinal distribution of sources) will dominate in our assessment of the accuracy of the heat flow determination.

Variable Characteristics: (1) Loki's hotter area(s), and (2) the outbursts in the leading hemisphere. The general level of flux from Loki changes, typically on time scales of months to years. Loki can be modeled using two anomalies with the smaller at a much higher temperature than the other. Variations in the temperature and areal exposure of the higher temperature anomaly are sufficient to explain the bulk of the observed variation, which is more pronounced at the shorter wavelengths. A major "outburst" (significant increase in 4.8 μm flux density over a short time), requiring a temperature in excess of 1,000 K, is shown in Fig. 1. More typically model temperatures in the range of 400 to 700 K can explain the observed flux densities.

The leading hemisphere also has shown changes in general emission level from apparition to apparition. This activity appears to be distributed in longitude and cannot be identified with a single source analogous to Loki. A number of spectacular outbursts have occurred on the leading hemisphere. As with the event in Fig. 1, they tend to be sufficiently hot to require the presence of silicate lava [7]. In the available data for well characterized outbursts (i.e., both temperature and size are known) from our program and other observations (i.e., see tabulation by [8]), there is an indication that longitudes of 70-80° W are preferred. Outbursts are apparently short-lived, lasting hours to days and are interpreted as local eruptive activity. Their sizes, typically in the 5 to 20 km range, are small compared to Io and to the sizes of the other geologic structures on the surface of Io. In our data set, outbursts occurred on ~ 5 percent of the nights we observed. Outbursts occur infrequently and they contribute only a little to Io's global heat flow due to their small size.

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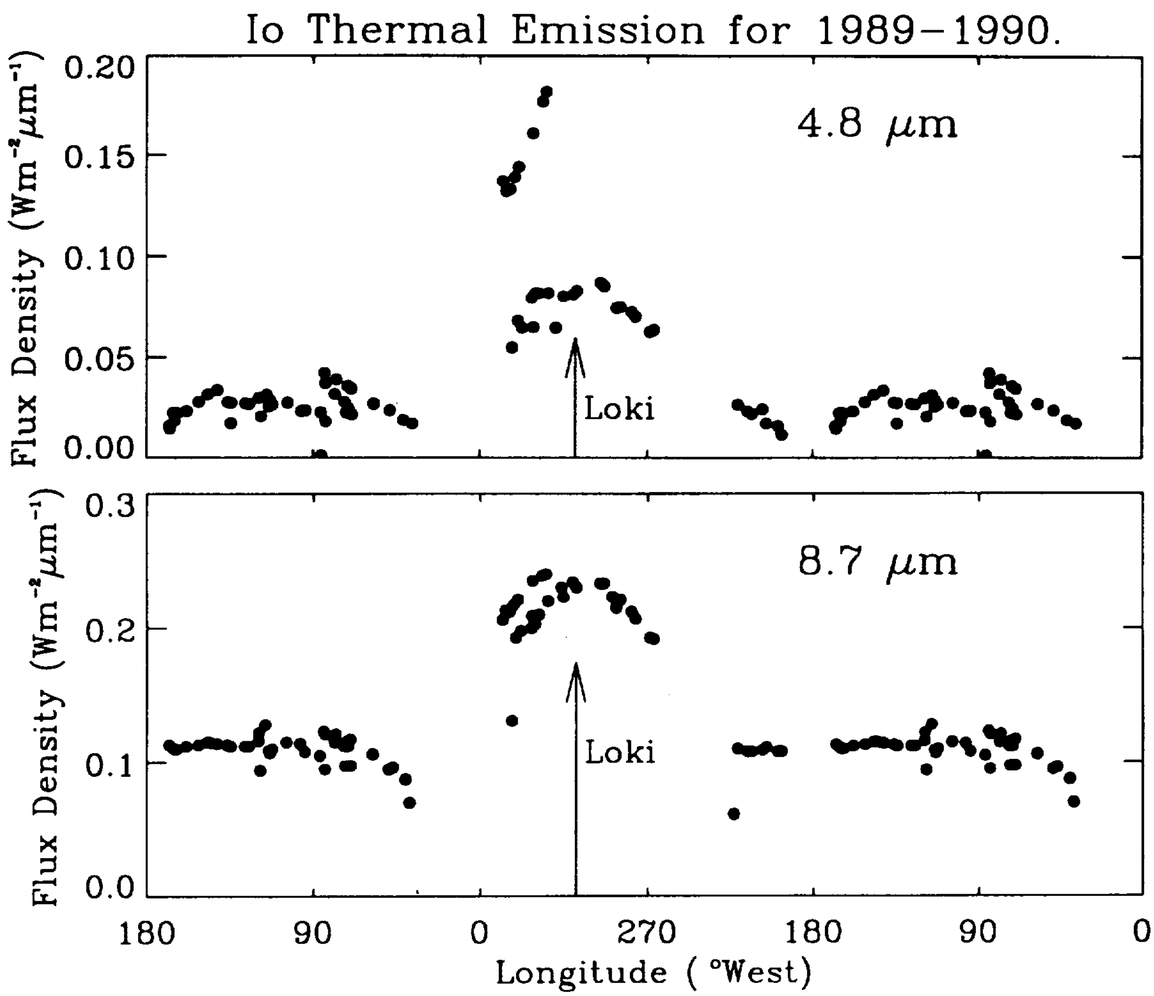

Fig. 1. Io's flux density (W m^{-2} μm^{-1}) versus West Longitude for infrared emission at 4.8 μm (with reflected sunlight subtracted) and 8.7 μm. The longitude scale spans 1.5 revolutions. Thus the observations between 0 and 180° are plotted twice. The longitude of Loki (309° W) is marked near the center of each panel. Hot-spot emission from this feature produces a characteristic peak in the lightcurves for each wavelength as it rotates across the central meridian of Io as viewed from the Earth. Such hot spots contribute their highest flux density near 8.7 μm and also produce most of the total power. During January 9, 1990 (UT) there was increased emission from an outburst while Io was near an orbital phase angle of 330°. Such outbursts briefly dominate the flux at wavelengths as short as 4.8 μm. The non-Loki hemisphere of Io remained quiescent during the intervals of our observations for the 1989/1990 apparition.